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ABSTRACT

A review was conducted of 16 research studies evaluating the effectiveness of computer assisted instruction (CAI) in teaching reading and language arts in the elementary school. The studies were of what K. A. Hall has termed "interactive instruction," which includes drill and practice as well as tutoring. Of the studies reviewed, 13 used at least one experimental (CAI) group and one control group. Of these, four evaluated CAI's effectiveness in teaching vocabulary or language, four the teaching of reading, three the teaching of spelling and reading, and two writing instruction. The three studies that did not use control groups evaluated the effectiveness of CAI projects concerned with the teaching of reading. Nearly all of the studies reviewed found that CAI not only was effective but was more effective than traditional methods for teaching reading, vocabulary, and language. Findings for the effectiveness of CAI in the teaching of writing and spelling, however, were mixed. (An extensive reference list is appended.) (Author/FL)

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COMPUTER-ASSISTED INSTRUCTION IN READING AND LANGUAGE ARTS

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Abstract

This paper reviews and critiques 16 research studies which evaluate the effectiveness of computer-assisted (CAI) in teaching reading and language arts in elementary education. The studies reviewed are the type that Hall referred to as "interactive instruction" which includes drill and practice instruction and tutorial instruction. Thirteen of the studies reviewed used at least one experimental (CAI) group and one control group. Four of these 13 studies evaluated the effectiveness of CAI in teaching vocabulary or language. Three others evaluated the effectiveness of CAI in teaching spelling and reading. Another four studies evaluated the effectiveness of CAI solely in the teaching of reading. The remaining two evaluated the effectiveness of CAI in teaching writing. The three studies which did not use any control groups were concerned with evaluating the effectiveness of CAI projects concerned with the teaching of reading. Nearly all of the studies reviewed found that computer-assisted instruction was effective and was more effective than traditional methods for teaching reading, vocabulary, and language. Findings for the effectiveness of CAI in the teaching of spelling and writing were mixed. An extensive reference list is included.

COMPUTER-ASSISTED INSTRUCTION IN READING AND LANGUAGE ARTS

Introduction

The purpose of this paper is to review studies which evaluate the effectiveness of computer-assisted instruction (CAI) in teaching reading and language arts in elementary education. The studies reviewed in this paper are the type that Hall (1982) referred to as "interactive instruction." During interactive instruction, a computer directly instructs the learner by presenting on a cathode ray tube (CRT) and/or through audio output material which has been stored within the computer's memory. After the material has been presented, the learner responds at his or her own rate by using the keyboard, a light pen, or a touch-sensitive panel. The computer accepts and evaluates these responses and provides feedback, usually indicating to the learner the correctness of his or her response. Based upon the learner's responses and the CAI program, the computer then presents subsequent instructional material.

Interactive instruction includes drill and practice instruction and tutorial instruction. The purpose of drill and practice is to provide review, practice, and feedback on skills and knowledge that the learner has already learned. Such programs present a fixed, linear sequence of material. The computer elicits a response from the learner by asking a question, and then it provides feedback (usually evaluating the answer) about the response the learner gave. If the response was correct, the computer reinforces the response and then presents subsequent material. If the response was incorrect, the computer gives

corrective feedback and/or provides additional clues to the correct answer.

Tutorial instruction, on the other hand, is intended to teach new skills and knowledge. This contrasts with drill and practice, which provides practice of skills and knowledge that have already been learned. Tutorial programs have the additional feature of branching, which has the effect of individualizing the program based on the learner's responses. The new material is usually presented in the form of text on the CRT. Then the learner is asked to respond to one or more questions presented by the computer. The computer evaluates the response(s) and gives the learner appropriate feedback. Based on the correctness of the learner's answer(s), the computer may present new material or it may continue to present questions, based on the circumstances of the individual learner. Because of the branching feature of the CAI tutorial program, it is not uncommon for a group of learners to have different sequences of material presented to each of them.

Studies Reviewed

Thirteen of the 16 studies reviewed used at least one experimental (CAI) group and one control group. Four of these 13 studies evaluated the effectiveness of CAI in teaching vocabulary or language. Three others evaluated the effectiveness of CAI in teaching spelling and reading. Another four studies evaluated the effectiveness of CAI solely in the teaching of reading. The remaining two evaluated the effectiveness of CAI in teaching writing. The three studies which did not use any control groups were concerned with evaluating the effectiveness of CAI projects

concerned with the teaching of reading.

Studies Using Two or More Treatments and a Control Group

This section is subdivided into the following three sections: Studies evaluating the effectiveness of CAI in teaching vocabulary or language, studies evaluating the effectiveness of CAI in teaching spelling and reading, and studies evaluating the effectiveness of the use of CAI with writing.

Studies evaluating the effectiveness of CAI in teaching vocabulary or language. In his study, Lally (1981) used 16 children (7 females, 9 males) who attended a special school for mildly and moderately mentally retarded. Their mean IQ was 60 and they were between 9 and 16 years old. The purpose of this study was to teach retarded school children a sight vocabulary using a computer that gave them verbal instructions and did not require them to use a keyboard. Students were placed in either the training or the comparison group which were matched for age, IQ, and initial sight vocabulary. Students in the training group were given 20-minute training sessions four times a week for four weeks, for a total of five hours of computer instruction. During Phase I of the training program, students could select any of the 16 words. The computer responded by lighting up the word and saying it. During Phase II (accessed by pressing another button), the computer told the student which word to press. The comparison group was not given any additional instruction. Both the training and comparison groups received their usual classroom instruction which included the teaching of the same words. Thus, the CAI was more like a drill and practice program than a

tutorial program.

Students' sight vocabulary was assessed immediately after the four-week training program and again 4, 8, 16, and 23 weeks after the program. The last assessment was made in the second week of a new school year following a seven-week vacation.

Two-way analysis of variance showed that the difference between the groups over the first five assessment sessions was significant ($p < .01$). The scores for the students in the training group did not decline in the sixth assessment session, though the scores for the comparison group did decline. Given these results, the researcher concluded that the training program resulted in considerable long-term gains.

Atkinson (1968 a, b) used 100 first graders from "culturally disadvantaged" homes who attended the Brentwood School in East Palo Alto, California in his study. The purpose of the study was to evaluate the Stanford CAI (computer-assisted instruction) reading project that was tutorial in nature. Instructional tasks within each lesson included decoding skills, comprehension skills, and games and other motivational devices. Half of the students took reading lessons using CAI, while the other half were taught reading by a teacher in the classroom (but also received CAI lessons in mathematics). The students in the CAI group were initially given only brief CAI lessons each day, but the lesson length was increased to 20 minutes daily after the first six weeks and to 30-35 minutes daily during the last (seventh) month. Atkinson reported four major findings. First, boys and girls progressed at equal rates through the self-paced material. Second, boys and girls scored similarly on all but the

following type of problem: Girls scored significantly higher than boys on the word list section of the CAI lessons (essentially a paired-associate learning task). Third, though the scores the two groups received on the California Achievement Test (CAT) given before the project began did not differ, the scores on the CAT given late that spring did differ significantly. The CAI group scored 7.6 points ($p < .01$) above the other group on the vocabulary section and the total score tally of the CAT. The fourth finding Atkinson reported was the observation that the students' span of interest at the CAI terminal was more than 30 minutes when the instructional sequence was adaptive to their responses.

Spring and Perry (1981-82) formed three age-matched groups of students from six public elementary schools. The training group contained 12 educationally handicapped students with a mean age of 9.1 years. The control group contained 12 educationally handicapped students with a mean age of 9.7 years. The normal group contained 12 students from regular classes and had a mean age of 9.2 years. The purpose of their study was to develop a computer assisted instruction (CAI) system for use on a microcomputer which would drill educationally handicapped children on word-decoding skills, yet allow the teacher to design exercises to fit the needs of individual students.

All students were given the following three types of word reading lists as pretests and posttests: Three lists of CVC nonsense or real words (each containing ten words) one list of ten real CCVC/CVCC words beginning or ending with a consonant

blend, and one list of ten real CVC words beginning or ending with a consonant diagraph. In addition, a daily log was kept for each student in the training group to record decoding tasks successfully completed, to describe learning problems, and to record spontaneous comments and behaviors reflecting positive or negative motivation.

Students in the training groups received 10-minute CAI sessions daily for two months in addition to the regular classroom instruction that all students received. The control and normal groups received no additional instruction. The mean scores on each of the three pretests indicated no significant differences between the control and the training groups as determined by F tests ($F < 1$ for each comparison). The mean scores on the three pretests for the normal group were significantly higher as determined by F tests than the corresponding mean scores of the control and training groups ($p < .001$ for all comparisons). Analysis of covariance showed that the posttest scores of the training group were significantly higher than the scores of the control group for CVC words ($F(1,19)=15.1$, $p < .001$) and for CCVC/CVCC words ($F(1,19)=6.76$, $p < .025$). There were no significant differences for the two groups for the CVC words containing diagraphs. A chi-square test of changes in statements recorded in daily logs indicated that the decrease in positive statements (from 49 to 37) and increase in negative statements (from 14 to 18) from the first month to the second month was not significant ($X^2=1.15$, $p > .20$). The researchers concluded that CAI training significantly improved word decoding ability of the students and established high motivation for learning which did not

significantly decrease during the two month training period.

Wilson and Fitzgibbon (1970) studied fourth- and fifth-grade students to evaluate the implementation of the Title III Project INDICOM, a computer-assisted instruction (CAI) project composed of drill and practice lessons. The students in the experimental group and in control group I attended the same elementary school in Pontiac, Michigan, while students in control group II attended another elementary school not involved in a study implementing CAI. The experimental group consisted of 68 students who received CAI in English and mathematics. Control group I consisted of 42 students receiving drill and practice only in mathematics. Control group II consisted of 77 students who were instructed with traditional methods. Each group received equal amounts of time devoted to language arts instruction. Tests conducted on the mean IQ's for each group obtained from the California Test of Mental Maturity showed no significant differences among the groups. The language suotest of the Standard Achievement Test was given before the study began in February and after the study concluded in June. During the four months of the study, the experimental (CAI) group gained seven months and control groups I and II gained three months on the SAT. These results were evaluated using the Kruskal-Wallis one-way analysis of variance which indicated that the values obtained for posttest ranks was significant beyond the .05 level. In addition, teachers kept logs to record comments, student reactions, instruction, and student performance relating to the CAI. All comments were positive. Students enjoyed the programs; teachers enjoyed the time the

programs saved them and reported better performance from students.

These four studies compared the effectiveness of CAI versus another method in teaching vocabulary or language. Atkinson (1968 a, b) and Wilson and Fitzgibbon (1970) used normal classes. The students in these two studies received either CAI lessons or lessons using more traditional instructional methods. This contrasts to the studies of Lally (1981) and Spring and Perry (1981-82), who used handicapped students as subjects and used CAI lessons in addition to regular classroom instruction. It is not surprising that significant differences favoring CAI instruction were found between the groups in the latter studies, since the students in the CAI groups were receiving additional instruction beyond that received by the control groups. However, significant differences that favored the CAI groups were also found in the first two studies, and that contributes to the belief that CAI is more effective than traditional methods for teaching some skills. While evaluating attitudes towards CAI, Spring and Perry found no significant changes from the first to the second month, while Wilson and Fitzgibbon found that students only made positive comments about CAI.

Studies evaluating the effectiveness of CAI in teaching spelling and/or reading. Three studies evaluated the effectiveness of CAI in teaching spelling and/or reading and used at least one experimental (CAI) group and one control group. In her study, Robertson (1978) used 36 third-grade students who were identified by the Schonell S1 Spelling Test (S-S1A) as the poorest spellers in their grade in three schools. The Visual

Sequential Memory subtest (VSM) of the Illinois Test of Psycholinguistic Abilities (ITPA) was given to match the students in threes. The matched students were then assigned to one of three groups. Words, an experimental group, used computer-assisted programs emphasizing meaningful words. Letters, another experimental group, used computer-assisted programs emphasizing nonmeaningful words. N Facts, the control group, used a computer-assisted arithmetic program. The VSM scores were used to divide the students into the following two equal groups: those with the highest scores (V+ group) and those with the lowest scores (V- group). Form A of the Gates Mckillop Spelling Test was given individually to the students. Errors made on this test and those made on the S-S1A were analyzed and classified. The students were given 15 minutes each day to work on their computer-assisted programs; most of them obtained a total of five hours and 25 minutes of instruction during the five-week study.

Students were then given as posttests the Gates McKillop Spelling Test Form B, the S-S1A, the Schonell S-S1B, and the VSM of the ITPA. The study used a posttest-only, control group design. The students were divided according to which of the three treatments they received and whether they were classified V+ or V-. Data from the posttests were analyzed using a Lindquist Type I Analysis of Variance. There were no significant differences in the mean posttest scores of spelling achievement among the three treatment groups or between the V+ and V- groups. In addition, no significant difference was found between the treatment groups when the patterns of errors in the pretest and

posttest were compared. For all groups, the average gain in spelling ability was 5.6 months. Students made many positive comments about the programs and most were as eager to work on the computer at the end of the study as they had been at the beginning of the study. Though students criticized the computer, none said they did not enjoy working on it.

The author concluded that children enjoyed the computer-assisted programs and that sequential memory training developed the skills necessary in spelling, whether the training used number equations, meaningful words, or nonmeaningful words.

Lysiar and his collegues (1976) used 2,298 students in grades three through seven from eight elementary and four middle schools to evaluate the computerized curriculum developed by the Computer Curriculum Corporation of Palo Alto, California. The purpose of the study was to determine if computer-assisted instruction (CAI) was a more effective supplemental method of teaching than other Title I programs. Students who qualified for Title I were given CAI instruction in reading and mathematics for ten minutes each day during the seven months of the study. Students were given the following tests in Fall and Spring: Iowa Test of Basic Skills - Vocabulary, Reading, and Spelling Subtests (ITBS), Criterion Referenced Reading Test, and Gates-MacGinitie Reading Test.

Analysis of covariance was applied to adjust the Spring test scores for group differences in the Fall test scores. The results showed that the scores on the Reading and Vocabulary Subtests of the ITBS for the CAI group were significantly higher than those for the resource teacher group for the third grade

($p < .01$). Scores on the Vocabulary and Reading Subtests of the ITBS for the fourth-grade resource teacher group and scores on the Vocabulary Subtest of the ITBS for the fifth-grade resource teacher group were significantly higher than those for the respective CAI groups ($p < .05$). Scores on the Vocabulary Subtest of the ITBS for the sixth-grade resource teacher group were also significantly higher than those for the CAI group ($p < .01$). The test scores for the sixth-graders on the Spelling Subtest of the ITBS showed no significant differences between the CAI and the resource teacher groups. On the Gates-MacGinitie Reading Test, the scores for the sixth- and seventh-grader CAI groups were significantly higher than for the resource teacher groups (sixth-grade $p < .05$, seventh-grade $p < .01$). In addition, the CAI group made an average gain of seven months during the seven months they received the computer-assisted instruction.

Fletcher and Atkinson (1972) used 25 matched pairs of first-grade boys and 25 matched pairs of first-grade girls in their study to evaluate the computer-assisted instruction (CAI) reading curriculum. The matching was based on two factors, the students' Metropolitan Readiness Test (MRT) scores and their teachers' comparable ability. The CAI reading curriculum was divided into seven content areas called strands which taught decoding skills and word and sentence comprehension. The experimental member of each matched pair of students received eight to ten minutes of CAI instruction each school day for five and one-half months. The control member of each pair received no CAI instruction. All other activities during the school day were similar.

At the end of five and one-half months, the California Cooperative Reading Test (COOP), four subtests of the Stanford Achievement Test (SAT), and seven subtests of the CAI Reading Project Test (DF), a test developed at Stanford to evaluate the goals of the CAI reading curriculum, were administered as post-tests. Multiple t tests on the posttest scores showed that both boys and girls in the CAI group received significantly higher scores on the SAT and the DF, and the boys in the CAI group also scored higher on the COOP than did their non-CAI counterparts. Analysis of scores of the four subtests of the SAT indicated that both girls and boys in the CAI group received higher scores on the word reading and the paragraph meaning subtests and the CAI boys also scored higher on the word study subtest than their non-CAI counterparts. Both girls and boys in the CAI group did better than the group receiving no CAI instruction on four of the seven subtests of the DF (uppercase letters, lowercase words, spelling patterns, and spelling nonsense syllables) and the CAI boys also did better than the boys in the other group on the spelling pattern words subtest. All the subjects obtained perfect or near-perfect scores on the two remaining subtests of the DF. The number of CAI reading items completed per unit time was correlated with the SAT, COOP, and DF. Correlations were high (.68-.84) for the SAT and the COOP, but they were lower for the DF (.48-.49). The effect of CAI on the progress of boys was compared with its effect on the progress of girls on each of the posttests. On the SAT, boys receiving CAI instruction improved 22% in comparison with boys not receiving it, while the corresponding figure for girls was 20%. On the COOP, the

improvement for boys receiving CAI versus boys not receiving it was 42%, while the improvement for girls was 17%. Finally, on the DF the improvement for boys was 32%, and the improvement for girls was 13%. These data suggest that, while CAI instruction was effective for both boys and girls, it was more effective for boys. The researchers concluded that daily sessions of eight to ten minutes of CAI reading instruction resulted in significant improvements on posttest scores from statistical and practical standpoints.

Of these three studies that compared the effectiveness of CAI to another method of teaching spelling, only Fletcher and Atkinson (1972) concluded that CAI was effective in teaching spelling because the CAI instruction encouraged students to be analytical.

Atkinson (1974) followed the progress of students who, as first-graders, had been subjects in the Fletcher and Atkinson (1972) CAI study. California Cooperative Readiness Test (COOP) scores at the end of first grade showed that students who received CAI reading instruction showed a 5.05 month gain over the students who did not receive the CAI instruction. CAI reading instruction was not given during the second grade, but, at the end of that year, the difference was 4.90 months in favor of the students who had received the CAI reading instruction in the first grade. Thus, the initial difference observed was maintained during the second year, even when no CAI reading instruction was given.

Martin (cited in Brandt, 1981) developed a writing program

for the computer through which children learned to write and to read. Three treatments were compared. One group of first-grade students received instruction from a competent teacher using a standard basal reader. Another group of students received 30 minutes of the writing program plus 180 minutes of their regular basal reader program. The third group of first-grade students had only the writing program. At the end of the year, the students who received instruction from the teacher using the basal tested slightly above the 50th percentile, while students who received both basal instruction and the writing program tested at the 80th percentile, and those that had only the writing program tested at the 90th percentile. At the school which used only the writing program, the number of students retained in the first grade declined from 41 out of 126 to 19 out of 116.

Litman (1977) used fourth-, fifth-, and sixth-grade students to determine the effect that drill and practice computer assisted instruction (CAI) had on reading achievement after one year of instruction and two years after instruction. The Iowa Test of Basic Skills (ITBS) reading achievement scores at the end of the year of instruction and two years after instruction for students who had the CAI were compared to the scores of similar students who did not have the CAI. The analysis of covariance computed on the ITBS scores after the year of instruction gave significant F values for the main effects of instruction method and sex. Two years after instruction, the main effects of instruction method and grade level and for the interaction between instruction method and sex also had significant F values. Litman concluded that fourth- and fifth-graders who had the CAI instruction scored

higher on the ITBS after a year of instruction than did the non-CAI students and that males who had the CAI instruction scored higher on the ITBS two years after instruction than did the non-CAI males.

The computer-assisted instruction (CAI) project at Bath Elementary School (1979 a, b) was composed of one sixth-grade class of 18 students. The purpose of the project was to help the teacher provide individualized instruction through the use of the computer as an interactive instructional system. Students had their instructional reading levels taken at the beginning of the year, the beginning of the second semester, and the end of the year. The students received computer-assisted instruction for 20 minutes each day during the two months of the second semester. An average of 2.4 more months were gained during the semester the computer-assisted instruction was given than during the first semester. In addition, 93.7% of the answers on a student survey were favorable to the use of the computer.

Six of these studies compared the effectiveness of CAI to another method of teaching reading. All found CAI to be more effective than more traditional teaching methods for at least some students. Lysiar and his collegues (1976) found CAI to be more effective than instruction by a resource teacher for third-graders, but not for fourth-, fifth-, sixth-, and seventh-graders. Litman (1977) found CAI to be more effective than more traditional methods for fourth- and fifth-graders, but not for sixth-graders. The two studies which evaluated students' attitudes toward CAI found them to be favorable.

Studies evaluating the effectiveness of using CAI with writing. Two studies addressed this topic. Bradley (1982) used three groups of five or six above average first-graders in her study which investigated the use of microcomputer word processors in language experience lessons. After introducing the microcomputer, the researcher typed the students' stories into the computer as the students dictated them, rather than writing them on chart paper which is usually done during language experience lessons. The stories and lessons differed from typical language experience stories and lessons written on chart paper in the following ways: The stories ended after reaching logical conclusions, the stories were longer than the usual language experience story, students suggested changes and corrections in the stories as they told them, and the students reread the stories immediately upon receiving printed copies of them.

In their study, Woodruff, Bereiter and Scardamalia (1981-82) used 12 sixth-grade students (six males and six females) from two public schools located in a middle class suburban metropolitan Toronto area. The purpose of their study was to test the computer program CAC-1, which was designed to offer a variety of forms of optional assistance to students writing opinion essays. These forms of assistance included editorial and spelling assistance, prompts, sentence openers, and abstract element lists (lists of things to include in the essays).

The study was conducted over four consecutive school days. On the first day, the experimenter individually trained the subjects on the use of the computer and program for one and one-half hours. On the second day, the students were randomly

given one of two topics on which to write an argument using paper and pencil. On the third day, the students were given the remaining topic on which to write using the CAC-1 program. On the final day, the students were interviewed individually.

Analysis of variance indicated that composing using the computer took significantly more time than using paper and pencil ($F(1,8)=24.6$, $p < .002$). However, when the amount of time spent using the computer's help was subtracted from this total, this difference was not significant. There were significantly more sentence openers in the computer condition than in the paper and pencil condition ($F(1,8)=100.5$, $p < .001$). No significant differences were found between the two conditions for the number of words produced or for the quality of papers produced (as rated on a one to five scale by two raters whose inter-rater reliability correlation coefficient was .52). However, there was a significant sex by condition interaction on the quality of papers produced which showed females to be superior to males in the paper and pencil condition ($F(1,8)=8.03$), $p < .022$). Students used significantly more of the abstract element list help and more sentence openers help than they used of all other types of help (help producing the next sentence, reprinting text, changing words, and checking for unsure words) combined ($t=4.62$, $p < .071$). Students also indicated that they liked writing using the computer significantly better than using paper and pencil ($t(22)=3.13$, $p < .005$) by their responses on a nine-point rating scale. In addition, 66.6% of the students reported that it was easier to write on the computer. Though 75% of the students said

they could write better on the computer, only 33.3% thought they did write better. The authors concluded that sixth-graders perceived the computer to make writing easier, better, and more enjoyable, but the use of the computer did not improve the quality of the writing compositions.

These studies report conflicting findings. Bradley (1982) found that use of the computer helped first-graders to produce better quality stories, while Woodruff, Bereiter and Scardamalia (1981-82) found that use of the computer did not affect writing quality. The latter study did find that students enjoyed writing using the computer and thought is was easier than using a pencil and paper.

Studies Using Only CAI Treatment

Studies evaluating the effectiveness of CAI in teaching reading. Three studies evaluated the effectiveness of CAI in teaching reading using only a CAI treatment group. The reviews of these studies will be brief because primary sources could not be located.

Anelli (1971) studied the relationship between time spent on CAI reading and reading improvement, performance, and attitudes. The subjects in the study were 121 third- and fourth-graders who were attending three elementary schools in Newark, New Jersey. The students received reading instruction on the computer for either 20 minutes or 40 minutes and for a total of either less than four hours CAI or four or more hours CAI; the three levels of treatment were not defined in the abstract. The effects of various lengths of sessions and of total CAI received by the student were measured by posttest scores on the Stanford

Achievement Test (SAT) and by grade changes on the CAI program.

> Neither total CAI time nor length or frequency of CAI sessions appeared to affect reading achievement as measured by the SAT. Students receiving three to four hours CAI during a three month period made the greatest progress through the CAI program in proportion to the time spent. Girls in all treatment levels made the most progress in the CAI program . . . While subjects in this study also seemed enthusiastic about CAI, students were less enthusiastic after seven or eight hours accumulated machine time. (pp. 6662-A - 6663-A)

Hansen and his collegues (1971) developed a CAI remedial reading program that was used in primarily black, southern, poverty schools in northern Florida. During the first year, second and third grade students in this program made statistically significant grade level gains on the Slosson Oral Reading Test. They also improved their motivation and had positive attitudes towards the program.

Suppes and Van Compen (1968) found that students who participated in the Stanford-Brentwood reading project improved their attitudes and behavior and increased their understanding and application of reading fundamentals.

These three studies all found computer assisted instruction to improve reading skills, and found students' attitudes to be positive about using CAI.

Conclusions

Nearly all of the studies reviewed found that computer-assisted instruction was effective and was more effective than traditional methods for teaching reading, vocabulary, and language. Findings for the effectiveness of CAI in the teaching of spelling and writing were mixed. Seven of the eight studies that evaluated students' attitudes towards computer-assisted

instruction found that students enjoyed using the computer, and another study found that students' attitudes towards the computer did not change significantly from the beginning to then end of the study.

Most of the studies reviewed are comparative in nature. This design has many uncontrollable variables which complicate the explanation of the findings. One such factor, which could have been controlled more carefully than it sometimes was, is the total amount of instructional time given to the experimental and the control groups. Two studies (Lally, 1981 and Spring and Perry, 1981-82) used CAI in addition to regular instruction for the experimental group, while the control group only had regular instruction. Under most imaginable circumstances, groups that have had additional practice would tend to be expected perform better than the groups that have not have the additional practice. Indeed, this is what these studies found, but it is hard to interpret those findings as building a strong case supporting the effectiveness of CAI. Another factor is the quality of the instruction offered through the various instructional methods. In comparing CAI with traditional teaching methods, it is difficult to assess whether the quality (high or low) of the teaching produced the results that favored computer-assisted instruction. Similarly, CAI is not a single technique, but rather each CAI study centers on the application of one or several specific computer programs. In the few studies that found CAI not to be effective (or not as effective as another approach), the quality of the computer program might have contri-

buted to those results.

Studies on the effectiveness of CAI have yet to research variables associated with program characteristics (both as separate variables and also in relation to the student's age) such as length of the program, amount of text presented on the cathode ray tube (CRT) screen at one time, and the type of print used on the CRT. It appears that most CAI is effective in teaching reading. If the characteristics that make computer-assisted instruction effective can be isolated, more effective CAI may be produced in the future.

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